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Body Mass Changes and Voluntary Fluid Intakes of Keelboat Sailors

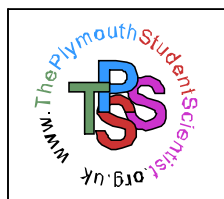
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Body Mass Changes and Voluntary Fluid Intakes of Keelboat Sailors

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2009

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Abstract

Match racing is a highly competitive and physically demanding type of keelboat racing which requires each person on board to have a specific job. There is little time for breaks to re-stock on fluid and nutrients lost, even when out training, therefore performance may be affected. The aim of this study is to see if keelboat sailors are adequately hydrated for sailing. 36 volunteers (30 males and 6 females) from the University of Plymouth Yacht Club match racing team took part in the study on four different occasions. Body mass and fluid intake was measured pre and post sailing as well as the amount of fluid that was taken sailing. Additionally urine samples were taken as a gauge of hydration status by measuring the amount, colour and osmolality of the urine. Results showed that the participants who were helming and doing bow drank on average over 1000ml and were positively hydration. Participants on main experienced 0.5% dehydration and only drank just over 400ml of fluid on average. Fluid intake of the participants varied greatly however the more fluid the participants took with them the more they drank. No correlation was found between fluid consumed and urine osmolality. Recommendations have been made that sailors should take with them and consume at least 1000ml of water to ensure the risks of dehydration and fluid loss are minimised.

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Chapter 1

1.1 Introduction

Sailing is a popular leisure time sport in many developed countries according to Spurway *et al.* (2007). It not only takes place on the sea, as expected, but also inland on lakes and reservoirs. In 2007 Spurway *et al.* stated that the governing body for sailing estimated that 500,000 people in the UK took part in sailing which is about 1.5% of the active population. There are many opportunities to take part in sailing, both recreationally and competitively, whether this is cruising on a yacht or day boat or racing a high performance dinghy. This study looks at sailors preparing to take part in a match racing event in keelboats. Match racing is a specific type of racing where identical boats battle against each other to gain an advantage over the opposition. Racing events can be very demanding on the body as there are normally several races held back to back in one day and there is little time available for breaks. This means that sailors need to adequately stock up on any nutrients lost during the events in the resting time available to them.

This study will look into whether sailors take with them and consume enough water to rehydrate whilst sailing. It will look into the background science for hydration as well as studies that have already been conducted in the area. It will also describe the data collection procedure and the results found.

1.2 Aims

The aims of this study are to determine if keelboat sailors are adequately hydrated for sailing in addition to seeing if there is a change in body mass.

1.3 Objectives

The objectives are to quantify body mass changes by weighing the participant's pre and post sailing and to measure the hydration status of the participants. This will be done by measuring fluid intake, urine output and osmolality after each sailing session. The data will be collected over a number of weeks which will allow a spread of data over different weather conditions.

Chapter 2

2.1 Background

Nutrition and hydration are fundamental aspects of day to day life and for athletes it is vital to get the right balance of fluids and nutrients so that they can reduce the affects of fatigue and prolong performance. Fatigue is detrimental to performance; causes of fatigue can include deficiency in nutrients for example carbohydrates, fats and water according to Williams (2007).

2.2 Water

Water is a key substance within the body; around 60% of body weight is made up of water according to Hoffman (2002). McArdle *et al.* (2007) identified water being in either intracellular or extracellular compartments. Water that is within a cell is classed as intracellular water and water that is outside the cells is extracellular. Williams (2007) split up extracellular water further into intercellular water which is between or surrounding the cells, and intravascular water which is contained in the blood vessels, see Figure 1.

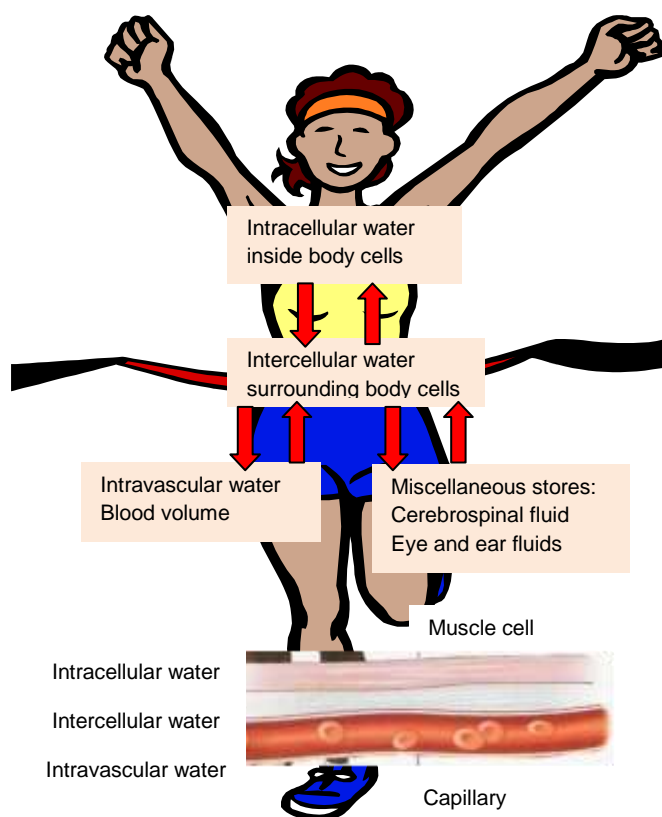


Figure 1 Body water compartments, adapted from Williams (2007)

Thermoregulation is the process of stabilising the body's temperature to within a few degrees of 37°C. The hypothalamus is the thermostat within the brain that regulates the body temperature (McArdle *et al.* 2007) and the process of homeostasis is to maintain a normal internal environment according to Williams (2007). Homeostasis also ensures the body has the appropriate amounts of water, electrolytes and hormones within the body for normal functions.

When exercising muscles produce energy which in turn gives off heat, the core body temperature can rise 2-3°C for marathon runners according to Maughan *et al.* (1995). Therefore the body will try to regulate the heat by a process called thermoregulation. This process is different for when the body is hot and when the body is cold. The way the body controls a rise in core body temperature is by radiation, conduction, convection and evaporation (McArdle *et al.* 2005). These are processes to try to lose body heat; Figure 2 shows the processes in action on a runner. Radiation is heat from the body being emitted out into the environment. Conduction is when heat is transferred through physical contact with a liquid, solid or gas. Convection is the transfer of heat by air or water over the body. Evaporation is when water from the skin and the respiratory tract turn into vapour and the heat is transferred into the environment. Additionally vasodilatation happens when the body is trying to lose heat and this is when the blood vessels get bigger to allow blood to flow to the skins surface to help with sweating.

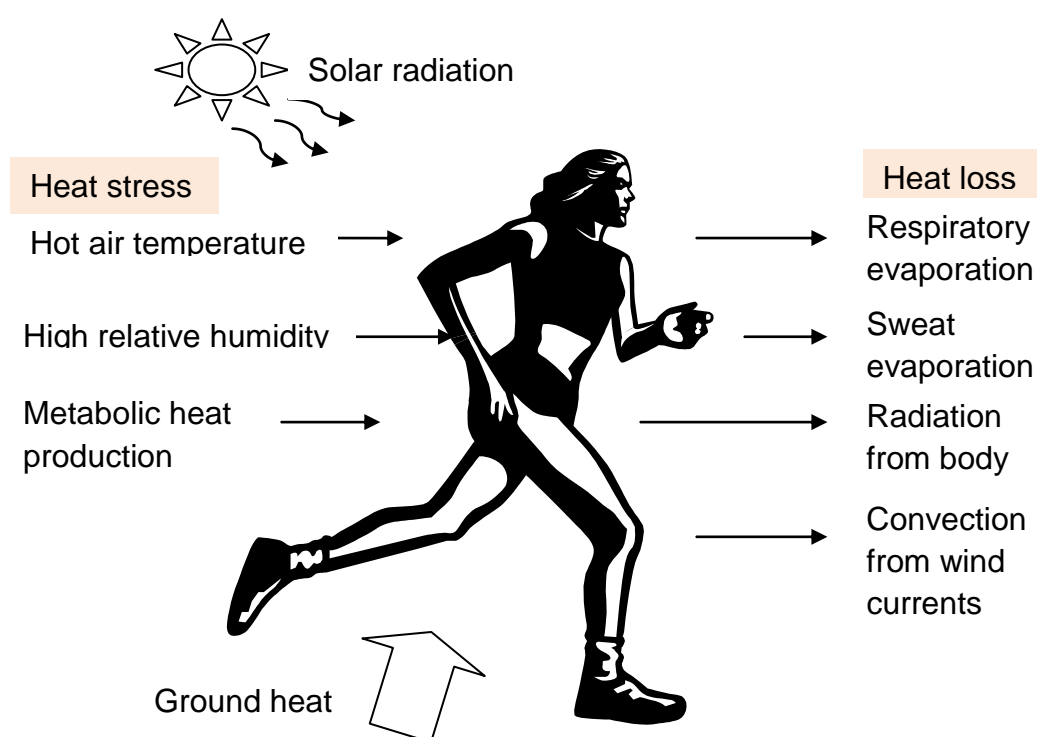


Figure 2 Sources of heat gain and loss during exercise, adapted from Williams (2007)

McArdle *et al.* 2007 says water can be lost from the body in one of four ways; in urine, in faeces, through the skin, and as water vapour expired in air. Williams (2007) highlights that urinary output is a primary route for water loss within the body, however evaporation is the main way the body controls excess heat when exercising. McArdle *et al.* (2007) point out that most fluid loss happens through sweating, this process uses extracellular fluid in particular blood plasma. McArdle *et al.* (2005) give an example of sweat loss over an hour period for moderate exercise being between 0.5 litres to 1.5 litres of sweat loss. This loss of fluid will need to be replaced as the British Nutrition Foundation (2000) suggests that when an athlete sweats, fluid and electrolytes are lost thus leaving the athlete dehydrated.

When the body is cold it will try to stop losing heat by increasing heat production and reducing heat loss according to McArdle *et al.* (2007). This is done by redirecting blood away from the skin which is cool and to the core to help maintain the core body temperature by vasoconstriction of the blood vessels. Vasoconstriction is when the blood vessels narrow. Also, the body will shiver to try to generate metabolic heat when it is cold (McArdle *et al.* 2007 and Williams 2007).

The terms euhydration, hyperhydration and hypohydration can be used to describe various water levels within a body. Dehydration and rehydration describe the process of water gain and loss respectively. Euhydration is the daily variation of water within a person, hyperhydration is a state of increased water levels, and hypohydration is a state of decreased water levels. Figure 3 shows the interaction between the different states of hydration.

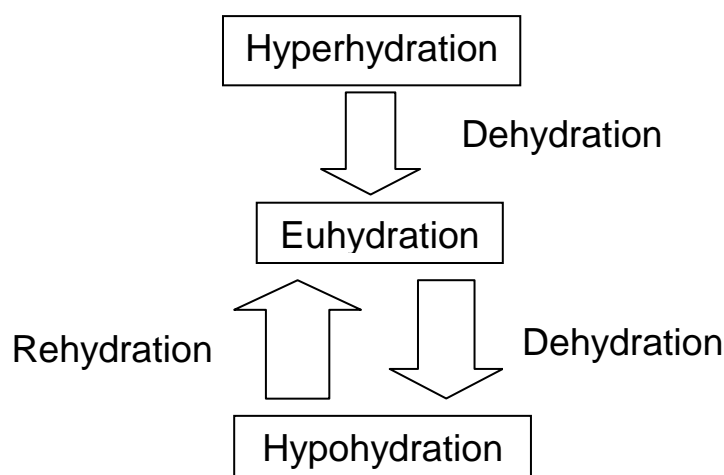


Figure 3 Hydration status interaction, adapted from McArdle *et al.* (2007)

Dehydration can lead to poor performance and diminished energy stores according to the website for the Gatorade Sports Science Institute [accessed November 2007]. Hopkins and Wood (2006) state that if exercise is of sufficient duration and intensity water and salt will be lost by the body. This can lead to reduced blood volume and flow, therefore less blood will be available for the muscles and skin, which in turn means less oxygen is delivered to the muscles. This will decrease performance of endurance athletes. Additionally Hopkins and Wood (2006) state that there is an increased risk of heat stroke to the athlete as a decrease in blood flow to the skin will reduce the ability to sweat and therefore lose heat. Neumann (2001) declares that functional disturbances within the body and reduced performance are attributes of major dehydration and in hot environments dehydration can lead to overheating. According to Birch *et al.* (2005) the affects of dehydration can include a reduction in stamina, power, speed and strength. Also, Birch *et al.* (2005) suggest that the more dehydrated an athlete is, the more the affects of dehydration are felt.

Many studies talk about the affects that a certain amount of dehydration can have on the body, Hoffman (2002) created a table that was adapted from Armstrong (1988) that shows physiological change within the body as well as the warning signs of dehydration.

Table 1 Physiological effects and Warning signs of Dehydration (Adapted from Armstrong 1988 as cited in Hoffman 2002)

Body weight loss (%)	Physiological change	Warning signs
0-2	Rise in core body temperature	None
2-4	Decrease in plasma volume, muscular water, stroke volume and blood flow to skin and muscles Increase in heart rate	Thirst, verbal complaints, and some discomfort
4-6	Decrease in sweat rate	Flushed skin, apathy, clear loss of muscle endurance, impatience, muscle spasms, muscle cramps, tingling sensation in arms, back and neck
6-8	Increase in urine acidity and protein in urine Decrease in blood flow to kidneys	Cotton mouth, headache, dizziness, shortness of breath, and indistinct speech
8-12		Swollen tongue, spasticity and delirium

Burke (1999) commented that there are guidelines produced about the recommended fluid and carbohydrate intake during exercise, however these recommendations are for sports with prolonged continuous exercise like running.

Noakes (1993) as cited in McArdle *et al.* (2005) made a criticism of athletes saying that the majority will only replace about one half of fluid lost whilst exercising if left on their own. The British Nutrition Foundation (2000) suggests that a drink containing 4-8% of carbohydrate, electrolytes and sodium is good to drink whilst training and for competitions. Both the British Dietetics Association (2004) and the Gatorade Sports Science Institute [accessed November 2007] recommend that an athlete drinks water or a sports drink every 15-20 minutes whilst exercising. Birch *et al.* (2005) suggest that an athlete should drink 200ml every 15-20 minutes during exercise in heat to rehydrate and after exercise an athlete should drink 1.5 x the fluid loss. Hoffman (2002) made recommendations for staying hydrated whilst exercises, they include: drink 0.5 L of water 2 hours before exercise, to force hydration whilst exercising, to drink fluids that are between 15-22°C and are flavoured, possibly drink glucose-electrolyte drinks as they can reduce fatigue and finally, that athletes should weigh themselves after exercise so they can replace all the lost fluid (1 L for every kg lost).

McArdle *et al.* (2005) suggest that coaches can test how hydrated athletes are by weighing them pre exercise and post exercise to see if there is any weight change as well as by measuring urine output and fluid intake. Hoffman (2002) agrees with this view as a loss in weight means the athlete will need to rehydrate themselves. Equation 1 represents the calculation described by both McArdle *et al.* (2005) and Hoffman (2002).

Equation 1 Change in Body Mass (as referred to by McArdle *et al.* (2005) and Hoffman (2002))

$$\text{Body Mass Change} = \text{Pre exercise weight (kg)} - \text{Post exercise weight (kg)}$$

As discussed previously the body uses the thermoregulation, in particular evaporation to dissipate heat. Knowing how much sweat an athlete produces will help enable the athlete to hydrate appropriately. The Gatorade Sports Science Institute as cited by Williams (2007) has produced a method to calculate sweat rate by using a the same part of the equation that McArdle *et al.* 2005 and Hoffman (2002) suggested to work out if a change in body mass occurred. The equation for working out sweat rate requires knowledge of pre and post exercise weight, the change in weight, fluid consumed, urine produced and exercise time. This equation assumes no food was consumed however this is not always the case in sport.

Equation 2 Sweat rate calculation (The Gatorade Sports Science Institute cited by Williams (2007))

$$\text{Change in body weight (kg)} = \text{body mass pre (kg)} - \text{body mass post (kg)}$$

$$\text{Change in body weight (g)} = \text{change in body weight (kg)} \times 1000$$

$$\text{Sweat loss (ml)} = \text{change in body weight (g)} + \text{fluid consumed (ml)} - \text{urine output (ml)}$$

$$\text{Sweat rate (ml/min)} = \text{sweat loss (ml)} \div \text{exercise time (mins)}$$

As cited by Slater and Tan (2007), there is another method of calculating sweat loss using the following equation from Cox *et al.* (2002). This equation takes into account of food consumed however it also requires the fluid to be measured in grams rather than millilitres as expected.

Equation 3 Sweat Loss calculation (Cox *et al.* (2002) as cited by Slater and Tan (2007))

$$\begin{aligned} \text{Sweat loss} = & (\text{pre exercise mass (g)} - \text{post exercise mass (g)}) \\ & + \text{food (g)} + \text{fluid intake (g)} \end{aligned}$$

Cox *et al.* 2002 (as cited in Tan and Sunarja 2007) also produce a calculation for the percentage dehydration, which will help to identify the warning signs of dehydration as previously examined (see Table 1).

Equation 4 Percentage Dehydration (Cox *et al.* (2002) as cited by Tan and Sunarja 2007))

$$\text{Percentage dehydration} = \frac{[(\text{pre sailing body mass} - \text{post sailing body mass}) \div \text{pre sailing body mass}] \times 100}$$

Another method of measuring how hydrated an athlete is, is to look at the urine osmolality and the urine colour of the athlete. The urine colour can be measured on a chart with the lightest colour representing good hydration and a dark colour indicating that rehydration is needed due to the possible onset of dehydration. Appendix 3 is a sample Urine colour chart produced by the Lucozade Sport and Lucozade Sport Science Academy. Urine osmolality looks at the concentration of water in urine; this study uses a Vitech Osmocheck. Vitech describe how the Osmocheck works by measuring the refractive index. This is indirectly related to osmolality but is directly

related to specific gravity. For a true reading of Osmolality an Osmometer should be used. The urine tested using the Osmocheck is measured in Osmols kg H₂O, this means osmolality per kg of water. A leaflet on the supplier's website, www.sports-science.co.uk [accessed February 2008] indicates that an athlete with a reading above 600 Osmols kg H₂O requires rehydration and if an athlete's urine osmolality reached 800 or over rehydration is essential. Figure 4 is from the supplier's website (www.sports-science.co.uk) and this illustrated the urine osmolality readings.

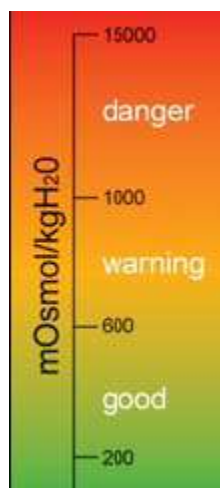


Figure 4 Urine osmolality chart (image: suppliers website www.sports-science.co.uk [Feb 2008])(courtesy of Vitech Scientific Ltd)

2.3 Energy

The amount of energy used by the body is called energy expenditure and this can be calculated to understand how much energy is used during exercise (Birch *et al.* 2005). As discussed, previous energy produced by the body can be the production on heat within the muscles. This heat production can be quantified as calories according to (Birch *et al.* 2005). 1000 calories is equivalent to 1 kilocalorie and this is the amount of heat that is needed to raise the temperature of 1 kg of water 1°C. McArdle *et al.* (2005) agree with this view and they indicate that 1 kg of water is the same as 1 litre of water and indicate that a kilocalorie can be expressed as a Kcal.

The metabolic rate is the amount of energy used to maintain the physical and chemical changes that happen in the body (Williams, 2007). Hoffman (2002) stated that during exercise the metabolic rate could rise between 5-20 times above its resting rate, this will result in an increase in body heat which must be removed to maintain homeostasis. Williams (2007) says during exercise the major demand for a muscle cell is oxygen and that oxygen consumption can be a measure of evaluating metabolic rate during exercise. Williams (2007) suggest that there is normally a linear relationship between an increase in exercise intensity and an increase in oxygen consumption. The cardiovascular system and the Respiratory system are primarily used for oxygen delivery to the muscles. The age, sex, level of fitness, type of activity, skill efficiency, percentage body fat and environmental issues all affect heart rate and therefore the metabolic rate (Williams, 2007). A MET is a multiple of the resting metabolic rate and is a measure of energy expenditure.

2.4 Nutrition

McArdle *et al.* 2007 state that too much body fat is dangerous when exercising in heat; this is due to fat acting as insulation. Therefore a healthy diet needs to be implemented so an athlete does not have excess body fat and overheat. There are a number of ways to determine if someone has an ideal body weight and composition. The body mass index is a relatively easy and widely used method to determine whether an individual has a healthy relationship between their height and weight (refer to Table 2). To work out BMI height and weight are needed, see Equation 5. The main drawback to using BMI is that it does not calculate body fat (Williams 2007). McArdle *et al.* (2007) indicate that BMI assumes that everyone is the same age, gender, ethnicity and race and this is not true so this could be a limitation of using BMI.

Equation 5 Body Mass Index (Williams 2007)

$$\text{Body Mass index} = \frac{\text{Body weight in kilograms}}{(\text{Height in meters})^2}$$

Table 2 An adaptation from Williams (2007) to show the Body Mass Index

<i>BMI</i>	<i>Weight Category</i>
18.5	Underweight
18.5 to 24.9	Normal
25.0 to 29.9	Overweight
30.0 to 39.9	Obese
40 +	Extremely obese

Other ways of obtaining body composition require more equipment than BMI but are generally more accurate, here are a few examples by Williams (2007) for alternative ways of measuring body composition and body fat: Skinfold thickness, underwater weighing, bioelectrical impedance analysis (BIA).

Therefore it is generally agreed that an athlete needs a healthy diet in order to maintain a healthy weight and therefore minimise the effects of overheating due to excess body fat. The Food Standards Agency (FSA) have recommendations for healthy eating, these contain the values of different food groups that a healthy adult should consume on a daily basis. This recommendation by the FSA will differ for athletes taking part in sporting activities due to their energy expenditure being greater than the average person.

The British Nutrition Foundation (2000) support this view by suggesting that training or competition can increase energy expenditure up to 3 times that of an average person. They go on to suggest that this increase is dependant on the athlete's body size, fitness levels and the type of sport they take part in.

Williams (2007) pointed out that food can be classed into 6 essential nutrient groups: carbohydrates, fats, proteins, vitamins, minerals and water.

2.5 Previous Research

Previous research into body mass changes and nutrient intake have been conducted in a wide variety of sports including team sports (Broad *et al.* 1996), running (Pugh *et al.* 1967 cited by Slater and Tan 2007), cycling (Robinson *et al.* 1995), ultra endurance events (Eden and Abernethy, 1994 cited by Slater and Tan 2007) and water based sports including swimming and water polo (Cox *et al.* 2002) and sailing (Tan and Sunarja, 2007 and Slater and Tan 2007).

Burke (1999) claims that team sports are different from sports that undertake prolonged exercise, which suggests that the data already published into fluid and carbohydrate intake is not applicable to team sports. These differences between the data already published and team sports may be due to team sports having high intensity exercise followed by low levels of inactivity as well as the workloads and playing characteristics differing from players to positions unlike in a sport with continuous activity like running or cycling. Burke (1999) also indicates that each match is a unique situation; the same can be said for sailing. Burke (1999) believes that performance is difficult to measure in teams sports; this may be true for sailing as well, due to the fact that both sailing and team sports depend on the opposition.

From the two studies that have already been conducted nutrient and fluid intake of sailing, one by Slater and Tan (2007) looked at dinghy club sailors and the other study by Tan and Sunarja (2007) looked at junior Optimist sailors both concluded that athletes experience levels of dehydration and nutrient deficiency whilst racing. Tan and Sunarja (2007) study used children racing in an internationally recognised boat, the Optimist and Slater and Tan's (2007) study used adult sailors competing at their local sailing club in a Laser or Laser Radial which is a one design boat used at the Olympics. Both these studies were conducted in Singapore where the weather conditions were hot and humid and are rated as Tropical Rainforest on the Köppen climate classification scale (1923). They both used similar methods for collecting data, Tan and Sunarja (2007) weighed the athletes' pre and post racing as well as assessing what the athletes consumed for breakfast and on the water by interviewing using dieticians. Slater and Tan (2007) also weighed the athletes' pre and post racing however instead of interviewing the athletes they weighed all food and fluid that was taken out sailing and then re weighed it on returning to shore. This method by Slater and Tan (2007) would give fewer margins for error when analysing the data. Slater and Tan (2007) also provided the athletes with a post race questionnaire to look at the perceived impact of nutrition in sailing amongst athletes.

Slater and Tan (2007) results found that fluid balance was negative, and fluid replacement was lower in males (37%) than females (62%). This supports the data collected from the questionnaire where the female athletes believed fluid intake had a high or very high impact on performance. This study by Slater and Tan (2007) disputes the values they recorded for sweat rates as this calculation took into consideration the total time on the water rather than the actual time spent racing. The carbohydrate intake of the athletes was low, varying between 0-87g.h⁻¹, Maughan (2000) as cited by Slater and Tan (2007) suggested the recommended intake should be 30-60g.h⁻¹ for exercise. Slater and Tan (2007) go on to acknowledge that a dietary assessment 24-48 hours before racing would have been useful.

Tan and Sunarja (2007) found that the average body mass loss was 0.5 kg which amounted to 1.3 litres of water loss during the days sailing. They noted that all of the athletes incurred some dehydration. Unlike Slater and Tan (2007), Tan and Sunarja (2007) tried to compare race score with dehydration, fluid intake or carbohydrate intake but they found no correlation. This may be because sailing is a sport that has many variables that cannot be controlled by the athlete, such as the opposition, this is similar to team sports and Burke (1999) found it hard to measure performance of team players in team sports.

Tan and Sunarja (2007) and Slater and Tan (2007) do not measure the hydration status of the sailors pre or post exercise and this could mean that they both have underestimated how dehydrated the athletes are. Tan and Sunarja (2007) recognise this saying that athletes may want to minimise their need to pass urine on the water.

A study into the energy balance and dietary habits of America's Cup sailors was performed by Bernardi *et al.* (2007) who found that energy expenditure differed depending on the job role in the boat and body mass of the athlete. They also found that the dietary intake of the athletes was not in line with recommendations from the American College of Sports Medicine, ACSM (2000). Both the values for protein and fat intake were greater than expected for very high activity exercise and the value for carbohydrate intake was much lower suggesting a deficiency. From this study recommendations were made to increase the sailor's carbohydrate intake to meet the recommendations of the ACSM (2000).

Bernardi *et al.* (2007) do admit that they could not measure all the data for the VO_2 of all the athletes as this interfered with the sail training plan already in place, therefore the data on energy expenditure for the sail trimmers will be inaccurate.

Previous studies carried out into body mass changes and nutrient intake in sailors lack information from different climate areas, the studies already carried out by Tan and Sunarja (2007) and Slater and Tan (2007) both look at these changes in sailors racing in a tropical region and not in a temperate climate, like Great Britain. Tan and Sunarja (2007) recommend that further research should be carried out in various climates and class of boats therefore this project will look at and compare the differences between the climates and boat types.

Boat type will be interesting to look into as Slater and Tan (2007) made an observation that there is limited space on a boat for food and fluid to be stored however in keelboats there is more space. Therefore keelboat sailors should have better access to food and fluid throughout a race and during the breaks thus keelboat sailors should be better hydrated and have consumed more nutrients than dinghy sailors. However the British Nutrition Foundation (2000) accepts that it can be physically difficult to consume enough food and drinks whilst taking part in sport.

2.5 Hypothesis

The hypothesis for this research is that sailors do not drink enough whilst sailing and in this case whilst training. This will leave the sailors with a negative weight loss indicating the need for rehydration. Additionally the participants' urine colour and osmolality will be high, which will also indicate the need to rehydrate in order to stop the effects of dehydration.

Chapter 3

3.1 Method

A study was carried out to look at the fluid intake of keelboat sailors whilst racing in order to understand if they were consuming adequate fluids. Thirty-six volunteers (30 males and 6 females) from the University of Plymouth Yacht Club match racing team took part in the study on 4 separate occasions. The weather data for the sailing sessions was obtained through the archive of Plymouth University MetNet data, this data is taken from the University campus not in Plymouth Sound. The male participants were aged between 19 to 21 years olds, were between 1.57 to 1.96 metres tall and weighed between 61.8 to 98.9kg. The female participants were aged between 19 and 22 years old, were between 1.6 and 1.73 metres tall and weighed between 60.7 and 86.7kg. The mean characteristics of the participants are displayed in appendix 4. The study was approved by the University of Plymouth's Ethics Board (see appendix 6) and all the participants were fully informed about the background and procedure of the study and signed a consent form (appendices 1 and 2).

The participants were weighed before the race training sessions in underclothes however in week 1 they were weighed in their waterproofs and shoes using Seca 880 digital scales with a precision of ± 0.1 kg. The participants were also measured to see how tall they were, so their body mass index could be calculated using Equation 5 cited by Williams (2007). The amount of fluid the participants took with them for the sailing session was also measured and noted. On return from the training session, the participants were weighed in the same clothes as previously and the amount of fluid left was measured and noted. Additionally the position that the participants sailed on during the day was noted so that different job roles could be compared. Appendix 5 describes the different job roles that take place on the boat. Participants were also asked on return to shore if they needed to evacuate their bladder and, if they did, the participants were asked to urinate into a measuring tube. The urine was then measured and the colour was compared to the Lucozade urine colour chart (appendix 3). The participants also were asked to take a sample of urine and place it onto a urine osmometer (Vitech Osmocheck) to measure the urine osmolality. The precision of the measurement was within ± 10 m Osmols kg H₂O. Additionally, participants were asked if they had evacuated their bladder or bowel whilst on the water.

Participants who had evacuated their bladder whilst on the water were excluded from all the sweat loss, sweat rate and percentage dehydration calculations as their data would affect the accuracy of the data.

3.2 Data Analysis

The data collected was analysed using various equations and mean calculations. The change in body mass whilst sailing was calculated using Equation 1 to see if there was any change in weight. The sweat rate of the participants was calculated by using Equation 2 to understand how much sweat the participants produced. Furthermore, Equation 4 was used to calculate the percentage dehydration of all of the participants.

A Pearson's two tailed bivariate correlation test was performed using SPSS 15.0, a statistical programme for Windows. This method will identify whether there are any correlations between the data collected.

Chapter 4

4.1 Results

Weather played a vital role in the ability to collect data; Figure 5 illustrates the average weather conditions over the four weeks when data was collected. The figure below is useful for comparing this research to previous research already conducted. Figure 5 shows the mean spread of data over each week and each data bar shows a value for either time spent on the water, the wind speed in knots, the force of the wind, the amount of rain and the temperature.

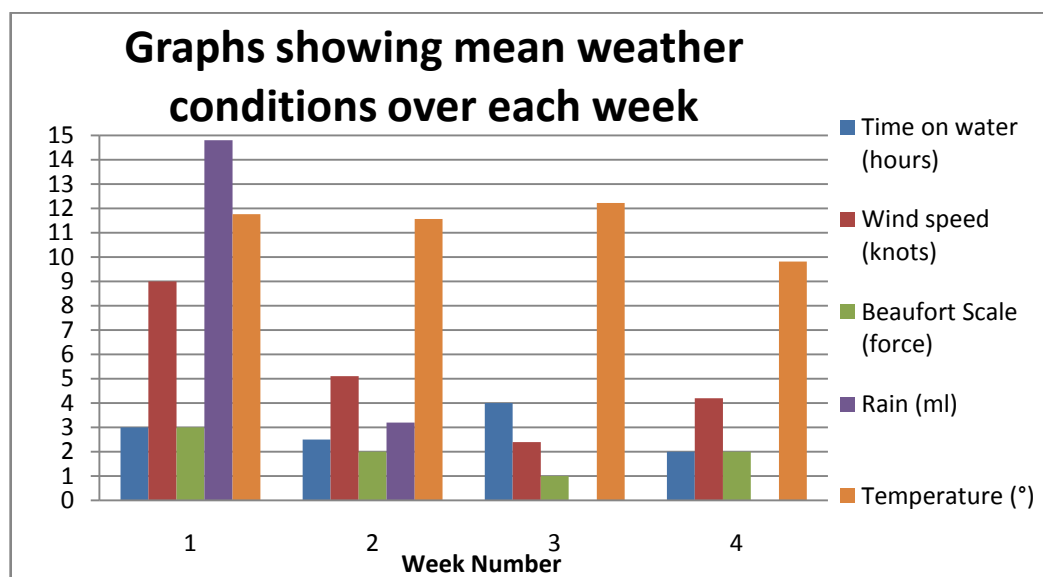


Figure 5 Mean weather conditions over the 4 weeks data was collected

Figure 5 illustrates the mean weather conditions for each week, Table 3 includes the quantitative values for the mean and the range of the weather data collected on each day when data was collected. This shows that each week the wind varied and was never constant.

Table 3 Mean values and range for wind speed, Beaufort scale and temperature for each week of training

Variable	Week 1	Week 2	Week 3	Week 4
Wind speed (knots)	(17.3 to 4.3)	(9.5 to 2.1)	4 (5.1 to 0)	(6.2 to 2.1)
Beaufort Scale (force)	3 (5 to 2)	2 (3 to 1)	1 (2 to 0)	2 (2 to 1)
Temperature (°)	6 (12.1 to 11.3)	(11.8 to 11.4)	(13.3 to 10.4)	2 (10 to 9.5)

During each week of data collection, the amount of fluid the participants brought sailing and consumed was measured to see if this was adequate. Figure 6 shows the variance between the fluid intakes each week. This shows that the most fluid consumed was during week 3 and the least during week 1.

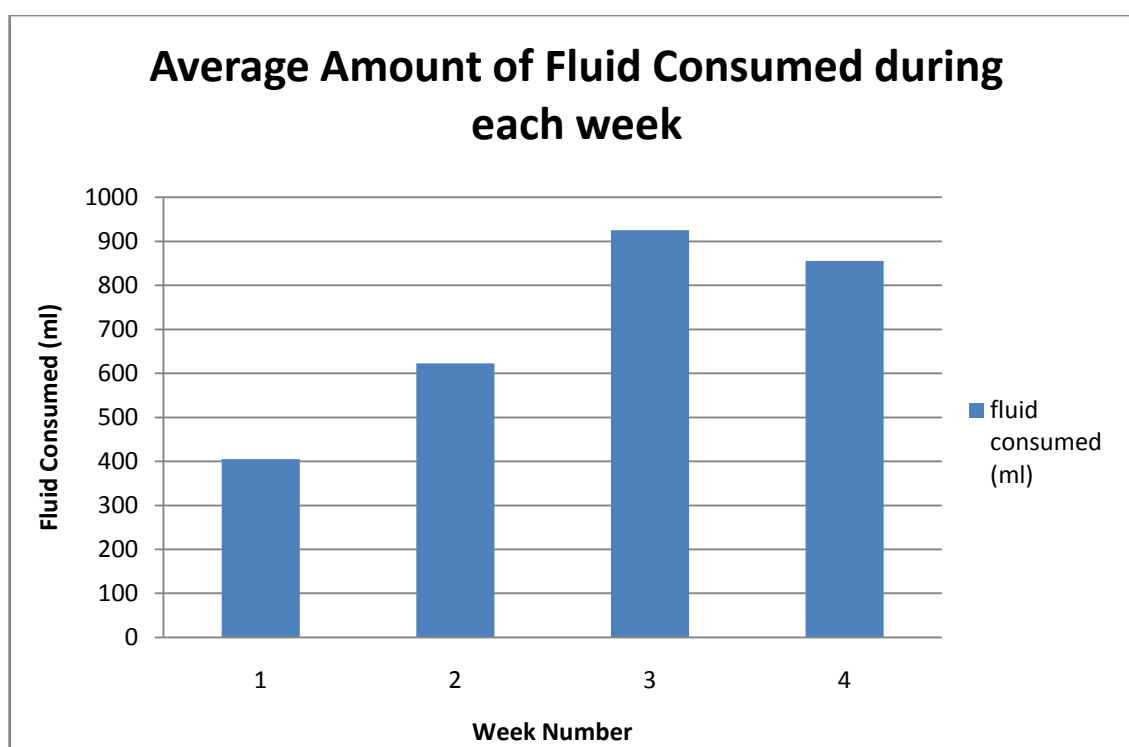


Figure 6 Mean fluid intake during each week

Figure 6 illustrates the mean fluid intake during each week however the raw data collected showed that there was a range of fluid consumed on the different occasions. Table 4 shows the range of fluid both taken sailing and consumed whilst sailing. This shows a wide variance between participants.

Table 4 shows the mean values and range of fluid taken and consumed whilst sailing each week

Week Number	Brought Sailing (ml)	Consumed whilst Sailing (ml)
1	925 (0 to 2000)	405 (100 to 1250)
2	622 (500 to 1500)	622 (100 to 1500)
3	925 (500 to 1500)	925 (0 to 2000)
4	944 (0 to 2000)	856 (0 to 2000)

Table 4 illustrates the range of fluid intake and it shows that the more fluid taken sailing the more is consumed. Figure 7 illustrates the correlation between the fluid taken sailing and the fluid consumed, this is useful for helping to understand voluntary fluid intake.

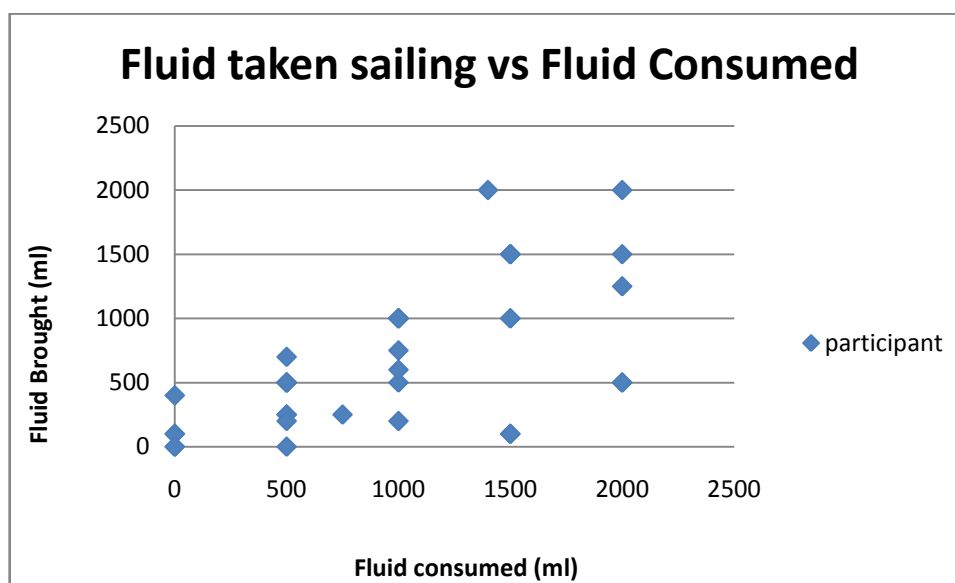


Figure 7 Correlation between fluid brought sailing and fluid consumed

Another way to look at the results was to see if there was any difference in the boat position and the fluid intake of the participants, Figure 8 demonstrates average fluid intake of participants sailing in each position over all 4 weeks. This shows that the participants doing pit or main consumed the least amount of fluid and the participants on bow consumed the most.

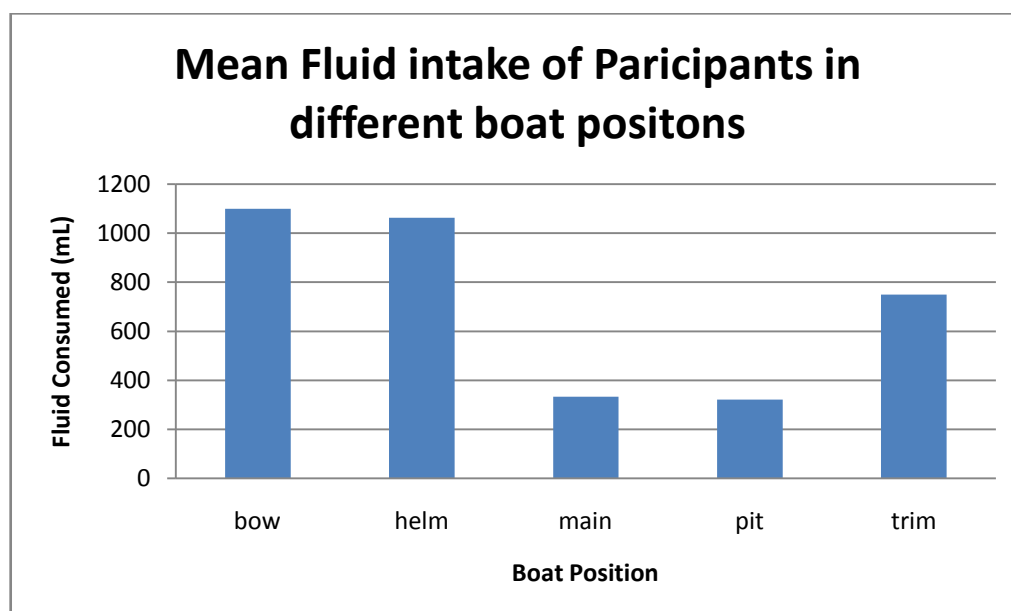


Figure 8 Mean fluid intake of participants in each position on the boat

As part of Equation 2 sweat loss was calculated, Figure 9 shows the correlation between the amount of fluid consumed and the sweat loss calculated. This indicated that the more fluid consumed the more sweat is lost.

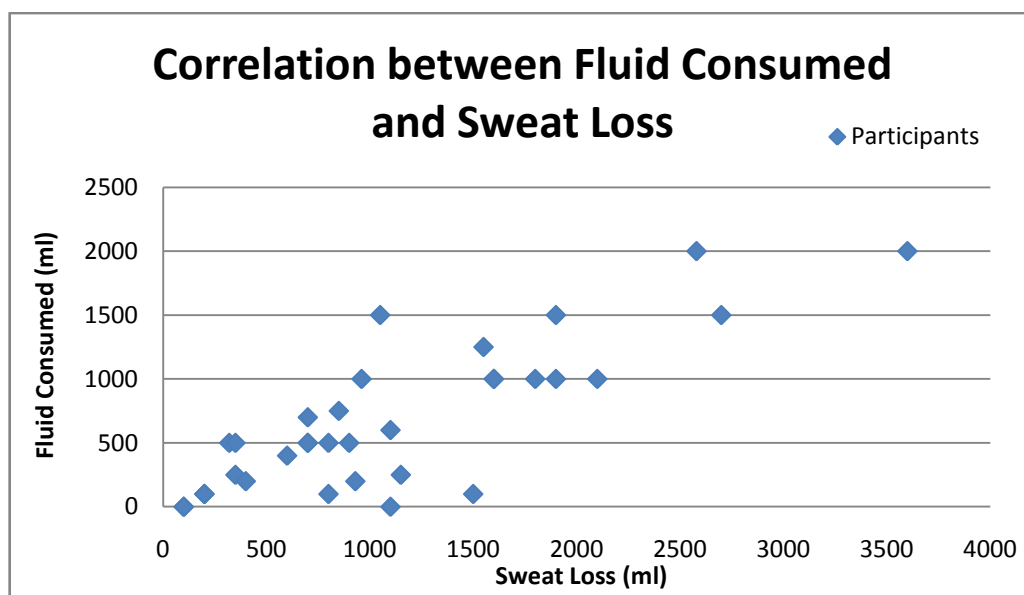


Figure 9 Relationship between fluid consumed and sweat loss

The warning signs of an athlete experiencing dehydration can occur with a 2% weight loss according to Table 1, therefore it is vital to know how much dehydration the sailors experienced. Figure 10 shows the mean hydration status of the sailors during each week. This shows that during week 3 the participants experienced some dehydration.

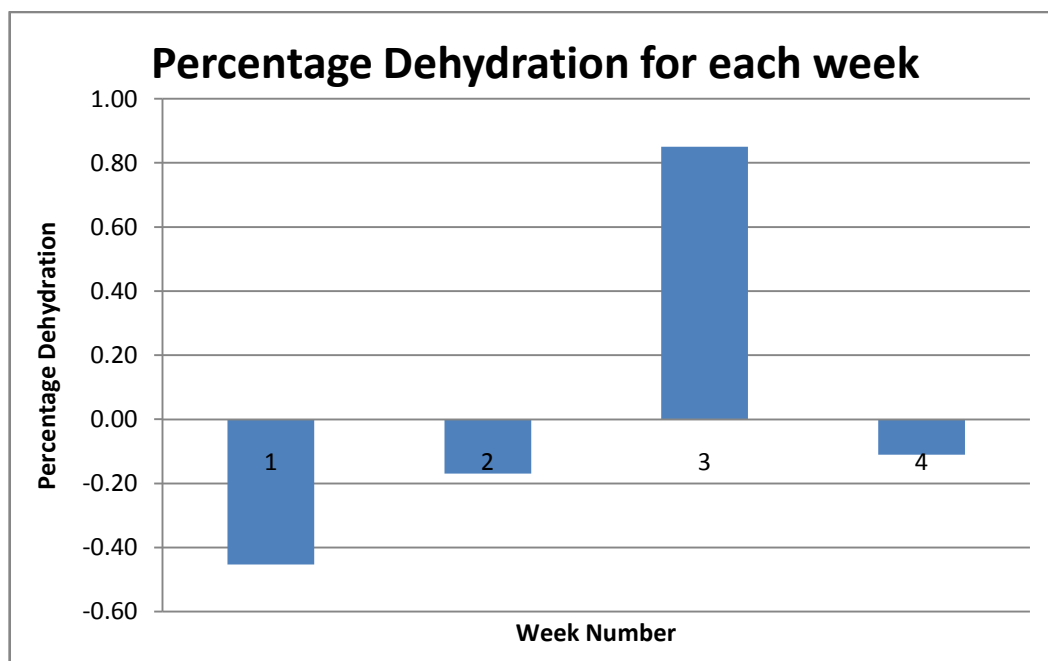


Figure 10 Mean percentage dehydration for each week

Figure 11 illustrates the mean percentage dehydration for each position on the boat during all four weeks. This shows that the participants doing either main or trim experience some dehydration however this is very marginal for the trimmers. This also indicates that the helms are most hydrated.

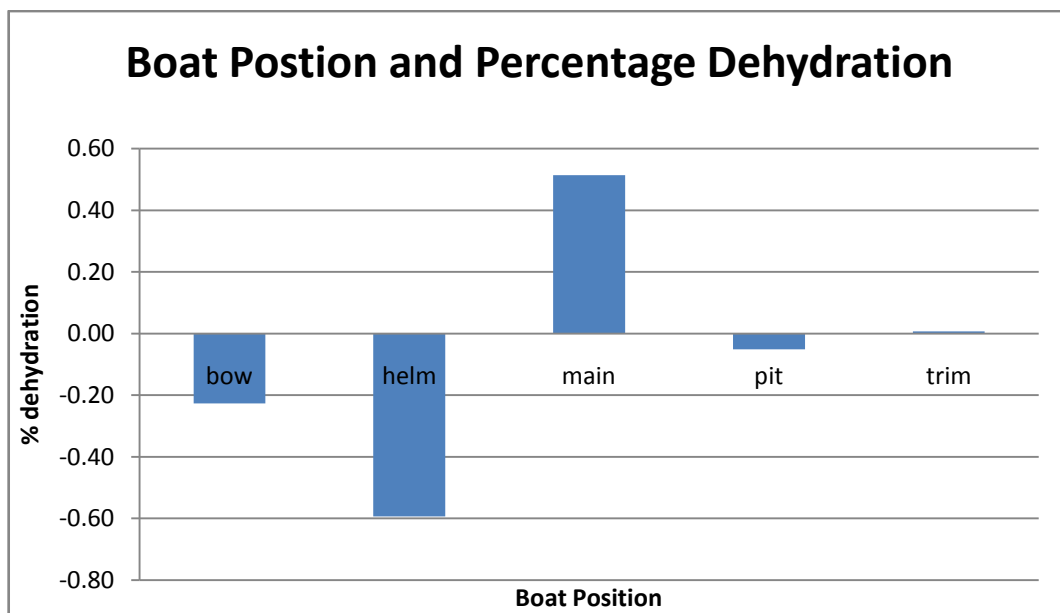


Figure 11 Mean percentage dehydration at each position on the boat

The correlation between weight change and percentage dehydration is shown in Figure 12. This demonstrates that a negative weight loss indicates dehydration.

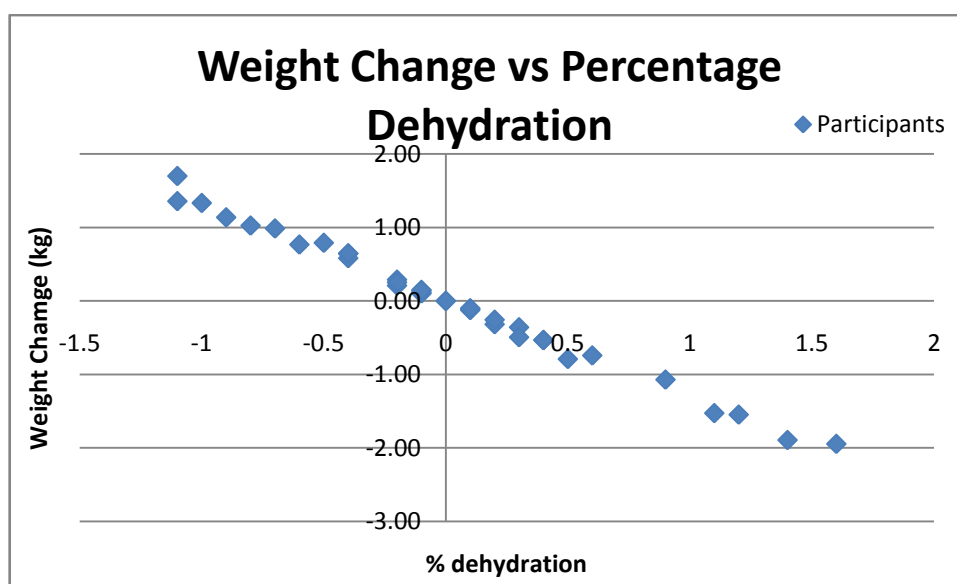


Figure 12 Correlation between weight change and percentage dehydration

The amount of fluid consumed and the weight change of each participant is shown in Figure 13. This figure shows that there is no correlation between fluid consumed and weight change and that there is a great variety in both the amount of fluid consumed and weight changes.

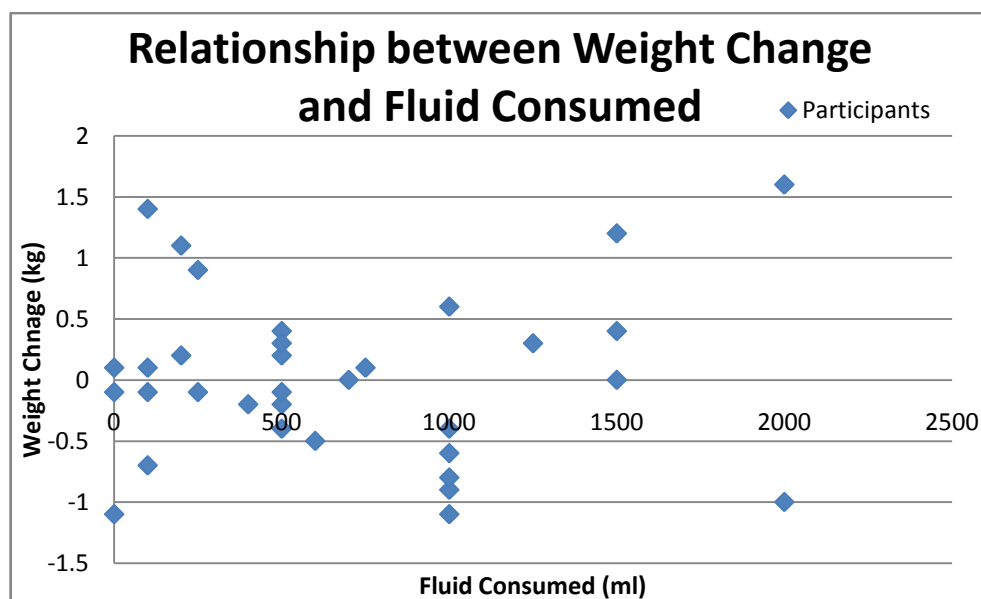


Figure 13 Weight change and fluid consumed of participants over all four weeks

Body mass was measured pre and post sailing to see if there was any difference, Figure 14 shows the average weight change of the participants each week. Figure 14 shows that in week 1, 2 and 4 on average all participants gained weight and during week 3 participants experienced an average of 0.6 kg weight loss.

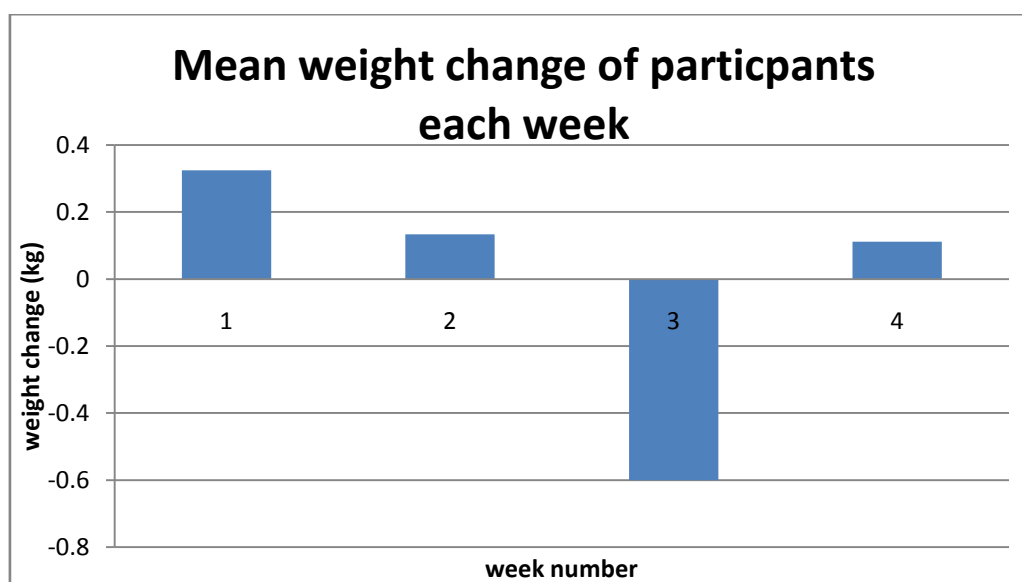


Figure 14 Mean change in weight of participants each week

As well as measuring body mass changes, urine samples were taken from volunteers. Figure 15 shows the relationship between the fluid consumed and the amount of urine produced. This does not show any correlation.

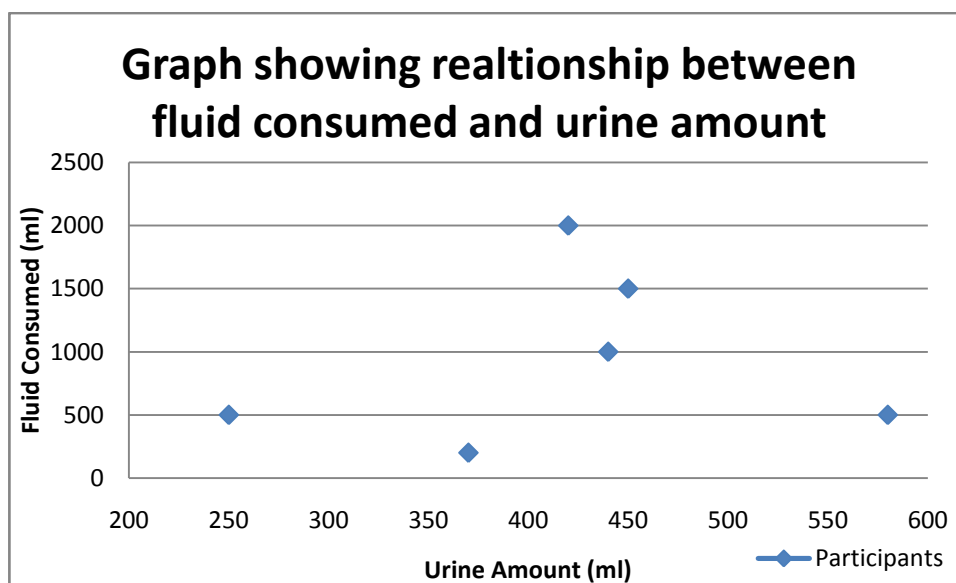


Figure 15 Relationship between fluid consumed and urine amount

Table 5 shows the raw data for the participants that gave a urine sample. This shows that only 6 participants out of 36 gave a sample and that there is a wide range of results that do not show anything conclusive.

Table 5 Urine Results

Variable / participant	Fluid Consumed (ml)	Urine Amount(ml)	Urine Osmolality (mOsmols kg H ₂ O)	Urine Colour
2	200	370	550	3
15	500	580	500	2.5
20	500	250	640	4
22	1500	450	660	5
27	2000	420	420	2
36	1000	440	200	2

See appendix 7 for the Pearson's bivariate correlation analysis.

Chapter 5

5.1 Discussion

Previous studies into fluid and nutrient intake of sailors have been conducted in Singapore; this study took part in England during January and February. Figure 5 shows that during the first 2 weeks of data collection there was rain fall, this didn't occur in both Tan and Sunarja (2007) or Slater and Tan (2007) research. In week 1 there was a total of 14.8 ml of rain and in week 2 a total 3.2 ml of rain with weeks 3 and 4 staying dry. Week 3 was the warmest week with an average temperature of 12.22°C and reaching a high of 13.3°C. Week 4 was the coldest week with a mean temperature of 9.82°C and hitting a low of 9.5°C. The longest time on the water was week 3 where the participants spent 4 hours out training. In week 4 the participants spent the least amount of time on the water only 2 hours. From the data in Figure 5 and Table 3, week 1 was the windiest with it reaching Beaufort force 5 at times. Table 3 shows us that week 3 had the least wind and both weeks 2 and 4 had a similar average wind speed. The results show that the research was conducted in a relatively cold climate, with the mean temperature for all weeks being 11.34°C. The mean temperature for Tan and Sunarja (2007) and Slater and Tan (2007) research was 31°C. Slater and Tan (2007), and Tan and Sunarja (2007) research took place in similar winds to week 1 of the research. However week 2, 3 and 4 all had less wind than the studies conducted by Slater and Tan (2007), and Tan and Sunarja (2007). This indicates that convection of the body heat was less likely due to less wind.

Figure 5 and Table 3 confirm that during the four weeks of data collection no week was identical to another and this reiterates the fact that each time a sailor goes sailing it will be a unique situation. Burke (1999) suggests team sports in particular matches are unique, Figure 5 and Table 3 confirm the fact sailing is similar to team sports for never having the exact conditions and situations reoccur.

Figure 6 shows that the most fluid was consumed in week 3 and the least consumed in week 1. The reason why more fluid was consumed in week 3 could be because the participants spent the longest time on the water therefore they had more opportunity to consume fluid. Furthermore week 3 was also the warmest week. Figure 6 also shows an increase in water consumed over each week this could be down to the sailors being aware of fluid intake being measured, more results would indicate if this is true or not.

Table 4 indicates that the more fluid the participants take sailing the more they seem to consume. It also shows that in weeks 1 and 4 some sailors didn't take any water sailing, however in weeks 3 and 4 some participants didn't consume any water. This means that in week 1 a sailor must have drunk someone else's water. This indicates that there are possible human errors that can occur as if the participants were sharing fluid then the results may not be as accurate as hoped. Additionally it shows that not all the water taken sailing gets consumed.

As mentioned before, Table 4 indicates that the more fluid the sailors took sailing the more they seemed to consume, Figure 7 illustrates this by showing the correlation between the fluid brought sailing and the fluid consumed whilst sailing. SPSS (see appendix 7) highlighted this correlation to be of significance of 0.001 ($p=0.00$, $r=0.645$). Therefore it is advisable for the sailors to take as much water as possible with them as this increases their chances of replacing any fluid lost and to maintain euhydration.

Figure 8 clearly shows that there is a difference in the amount of fluid consumed by participants in each position on the boat. This figure displays that the person who is on bow is consuming the most fluid, closely followed by the person helming, both consume on average over 1000ml. Compare this to the person doing pit who drinks on average 300ml, this is a big difference as it would be interesting if this difference in fluid intake could be quantified by the amount of work done by each position. This could be done by following a similar protocol to Bernardi (2007) to measure energy expenditure in sailors.

Figure 9 shows the correlation between fluid consumed and sweat loss. This shows as expected that the more fluid consumed the more water is lost from sweat due to the body regulating heat by the thermoregulation process discussed previously. The data presented in Figure 9 has a significance of 0.01 ($p=0.0$ and $r=0.820$) according to the Pearson's correlation test performed (see appendix 7).

The average estimated sweat rate calculated (see appendix 5) for the participants in the study was 432.19 ml/hr, this is higher than Cox *et al.* (2002) research into water polo players training. The water polo players sweat rate was 287ml/hr however Cox *et al.* (2002) suggested that there were errors in their data collection and that the sweat rates could be underestimated. Slater and Tan (2007) sweat rate calculation for the male participants was 465 ml/hr, this was calculated over the whole time on the water. Slater and Tan (2007) study took place in Singapore where higher sweat rates would be expected, this suggests that the estimates for the sweat rate of keelboat sailors could be over estimated. However, the keelboat sailors may have worked harder than the dinghy sailors in Slater and Tan (2007) study but this is not known because the amount of work done and energy expenditure is not measured in either study.

Equation 4 was used to work out the percentage dehydration that the participants experienced, Figure 10 showed that during week 3 the sailors experienced almost 1% dehydration with the participants experiencing no dehydration in the other week due to being positively hydrated.

As previously discussed, the relationship between boat position and fluid intake was examined in Figure 8 and Figure 11 shows the mean percentage dehydration of the sailors over all 4 weeks. This figure shows that the sailors on main as experiencing dehydration and therefore need to consume more fluid to prevent the negative affects dehydration give. This figure also shows that the sailors who are trimming experience minimal dehydration; they should be encouraged to drink more. Additionally this figure indicates that the participants who helm or do bow are consuming adequate fluid to avoid dehydration.

Figure 12 shows the correlation between weight change and percentage dehydration. This is significant to 0.01 where and $p=0.00$ and $r=-0.996$ which indicates a very strong negative correlation (see appendix 7) and Figure 12 illustrates this. The figure demonstrates that when the participants loss weight they experience some dehydration.

Statistical software (see appendix 7) concluded that there was no significant correlation between the weight change and the fluid consumed this is demonstrated in Figure 13. However an increase in the amount of data collected may then show a correlation.

Figure 14 shows that in week 1, 2 and 4 there is an average weight gain and in week 3 there is an average weight loss of just over 0.5kg. This body mass loss is similar to the mean body mass loss of Tan and Sunarja (2007) of 0.5 kg which they indicate is equal

to 1.3 litres of water lost.

Due to the limited data collected, no correlation was found for any of the urine samples collected. Urine samples should have been collected from all participants to gain a better understanding of hydration status.

Figure 15 illustrates that no correlation was found between the fluid consumed and the amount of urine. Additionally, SPSS found there to be no significant correlations for any of the urine results, this is probably due to the limited urine samples collected (see appendix 7).

Both Tan and Sunarja (2007) and Slater and Tan (2007) concluded that all participants in their studies experienced some dehydration however the same cannot be said for this research. Only a few participants experienced the beginnings of dehydration as Figure 10, Figure 11 and Figure 12 show, furthermore Table 5 highlights this by having 2 participants having the target urine colour (Lucozade Urine Chart see Appendix 3). On the other hand, only 6 participants gave a urine sample which is a small sample and therefore does not give an accurate measure of hydration, only an indication. Additionally, as previously discussed, the weather in England is significantly colder and therefore instead of overheating occurring due to dehydration the opposite could have happened and the other affects of thermoregulation like shivering may have occurred.

Tan and Sunarja (2007) indicate that athletes may minimise their fluid consumption to reduce their need to evacuate their bladder whilst on the water. This study found that participants were not out on the water all day but they were out for a significant period of time in some cases, which lead to a couple of participants having to evacuate their bladder whilst on the water. The boats the participants were sailing in did not have toilets on board and therefore too much fluid consumption could be an issue for some sailors. With this in mind a study looking at sailors sailing on a boat with a toilet may be useful to understand if this occurs.

Slater and Tan (2007) made an observation about for some sailor's space being an issue however the boats used for this research had plenty of space available. The results of Slater and Tan (2007) show that the mean fluid consumption was 1200 ml and all participants experience some dehydration. This fluid intake is almost the same as the mean for participants on bow, these participants were positively hydrated however, indicating that other factors play a role in hydration status, for example the weather or amount of work done.

Chapter 6

6.1 Conclusions

The data collected shows that more data would help to eliminate any deficiencies in the results, for example the inconsistent urine sample data. The results do prove that some sailors, in particular the participants that helmed or did bow, are drinking the right amount of fluid to stay hydrated. However this study does show that the participants who did main were experiencing dehydration and therefore need to drink more fluid. The results also show a great variation in fluid consumption each week and for each job role. This variation may be due to the nature of the activities being performed and the weather, however further research needs to be conducted to see if the job roles have different physical demands and therefore energy expenditure.

The results demonstrate that sailors should be actively encouraged to take and consume at least 1000 ml of water for a couple of hours sailing as results indicate that the more water taken sailing the more water consumed.

Improvements to the research could be to investigate a more accurate way of weighting participants as well as collecting more urine samples so to get a better idea of hydration status.

Further investigations should be performed to look at the energy expenditure in relationship to the job role and relate it to fluid intake. Furthermore the indication by Tan and Sunarja (2007) that sailors may be trying to minimise fluid intake due to not having the facilities to do so, therefore a similar investigation in Yacht sailors may be useful.

Chapter 7

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Appendices

The appendices to this report can be viewed in the folder 'Supplementary Files' located in the Reading Tools list that appears in the window to the right of this PDF document.